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(54) Fluid Control Valve and a Fluid Control System

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Description of Invention

This invention relates to a fluid control valve and a fluid control system for use in controlling a fluid operated apparatus such as a hydraulic prime mover such as a double acting hydraulic ram.

In known systems, fluid is pumped to an inlet of a control valve which controls the flow of fluid to one or more load outlets which is or are connected with the fluid operated apparatus. The control valve controls the speed and direction of movement of the fluid operated apparatus and it is usual to provide a control member such as a spool, which may be manually moved by a control lever, movement of the spool permitting the fluid to flow from the inlet either to the load outlet or to a drain outlet. Increased movement of the spool increases the flow rate through the valve to the load outlet.

An object of the present invention is to provide a new and improved fluid control valve and a new and improved fluid control system for use in controlling a fluid operated apparatus.

According to one aspect of the invention we provide a fluid control valve having an inlet, at least one load outlet adapted to be operatively connected to a fluid operated apparatus, a fluid flow path through the valve from the inlet to the or each load outlet, at least one control member to control the flow of fluid through the valve, and the at least one control member being selectively movable from a neutral position, wherein fluid is prevented from flowing from the inlet to the or

any load outlet, to an operative position, wherein fluid is permitted to flow from the inlet to a selected load outlet, and an operating member movable in response to the position of the or each control member to control the fluid flow from the inlet to the or each selected load outlet.

By providing such an operating member which controls the fluid flow in response to the position of the or each control member, a control valve in accordance with the present invention has the following advantages.

First, an improved control characteristic is obtained compared with known valves, that is to say, a predetermined flow rate is achieved at the or each selected load outlet for a predetermined movement of the control member, irrespective of the magnitude of the load and hence of the pressure at the load outlet.

Secondly it is not essential to provide pressure seals on the control member as leakage of fluid will not greatly adversely affect the control characteristic of the valve and thus, both due to this and as the fluid flow rate is controlled by the operating member, the forces exerted on the control member are reduced and thus the effort needed to move the control member is considerably reduced. This is of particular importance where the control member is directly manually movable.

Thirdly, parasitic losses associated with such valves due to, for example, friction between the fluid in the flow path and the valve, is reduced as it is possible to provide a more direct fluid flow path than with at least some known valves.

Some known valves, referred to as compensated valves, have a compensating spool to direct the fluid to a drain outlet of the valve or to a selected load outlet or outlets, in a proportion depending upon the load pressure; whereby the compensating spool adopts an equilibrium position with the load pressure and the fluid

pressure at the inlet, acting oppositely on the compensating spool, usually the fluid pressure at the inlet being maintained slightly higher than the load pressure.

By "load pressure" we mean the total pressure at the or each of the load outlets of the valve, imposed by the load or loads on the fluid system.

A valve in accordance with the invention may have such a compensating spool.

When the invention is applied to a compensated valve, the position of the main spool determines the difference between the inlet pressure and the load pressure which act in opposition on the compensating spool, hence movement of the main spool which increases the flow to the selected load outlet causes a reduction in said pressure difference so the compensating spool moves in the direction to reduce flow of fluid to the drain outlet thus providing more fluid for feeding to the load outlet. In this way, the flow rate of fluid to a load outlet is controlled independently of the load pressure.

A spring means may be provided to urge the compensating spool with the load pressure in a direction so that that inlet pressure is maintained slightly higher than the load outlet pressure.

Hitherto, the means to direct fluid at the load pressure to act on the compensating spool has comprised a separate sensing passage extending from the or each load outlet and communicating via a series of shuttle valves with the compensating spool.

This has the disadvantages of the expense of providing such passages and shuttle valves.

When the invention is applied to a compensated valve, instead of requiring the provision of the plurality of sensing passages and shuttle valves, the operating member provides a restriction in the flow path between the inlet and a gallery common to all load outlets to permit of a pressure difference between the

gallery and the inlet so that the pressure in the gallery can equal the load pressure, the fluid pressure in said gallery acting on the compensating spool.

Alternatively, the invention may be applied to a valve wherein fluid is supplied to the valve by a variable displacement pump, the pump rate of the variable displacement pump being automatically adjustable in response to a signal, derived from the position of the operating member, which is dependent on the selected position of the control member.

When the invention is applied to a valve the inlet of which is connected to a variable output pump, the position of the operating member determines the signal sent to a means, to change the output of the pump. In this way the flow rate of fluid to a load outlet is controlled independently of the load pressure.

Although not necessarily required, if desired a compensating spool such as that described above may be also provided.

In the first case, and in the second case where a compensating spool is provided, preferably fluid directed to the drain outlet of the valve is returned to a reservoir from where it is recirculated. However, there is often a small fluid loss in or at the fluid operated apparatus.

The operating member may comprise a main spool, a main spool chamber receiving one end of the main spool therein, the position of the main spool, being controlled by the pressure of fluid within the main spool chamber which acts on the main spool, fluid being fed to said main spool chamber from the fluid flow path of the valve, the pressure of fluid in the main spool chamber being dependent upon the selected position of the control member.

Resilient means may be provided to bias the main spool into a neutral position wherein fluid is prevented from flowing through the valve to a load outlet when the

pressure of fluid in the main spool chamber is insufficient to move the main spool into an open position.

Hence the pressure difference between the inlet and load pressure will be at a maximum, since flow of fluid through the valve will be zero, and hence when the main spool is in the neutral position, either the compensating spool will cause all the fluid to be fed from the inlet to the drain outlet or the output of the variable output pump will be at a minimum.

When the control member is moved to an operative position, the main spool will be urged against the force of the spring by the pressure of fluid in the main spool chamber overcoming the force of the resilient means.

A regulating spool may be provided to regulate the flow of fluid from the fluid flow path to said first chamber, the regulating spool having a portion in sealing sliding engagement with a regulating spool chamber of the valve into which it is urged by a spring means, means being provided to direct fluid from the flow path of the valve into the regulating spool chamber which communicates with said main spool chamber, to urge the regulating spool against the force of the spring means outwardly of the regulating spool chamber, said fluid directing means including a duct which, as the regulating spool moves outwardly of the regulating spool chamber in response to a sudden increase in load pressure, becomes increasingly blocked thereby reducing the flow of fluid to said main spool chamber and thereby preventing the sudden increase in pressure acting on the operating member.

Thus the pressure of fluid in the main spool chamber is maintained constant or substantially constant depending on the selected position of the control member, irrespective of any fluctuation in the pressure of fluid in the fluid flow path.

The regulating spool chamber may comprise a bore in the main spool, the main spool having a duct which, as the regulating spool is urged outwardly of the regulating spool chamber, becomes increasingly misaligned with the duct of the fluid directing means.

The control member may comprise a further spool, the fluid in the main spool chamber which acts on the main spool being in communication with the further spool so that when the control member is placed in said neutral position, the fluid in the main spool chamber is not pressurised to urge the main spool from said neutral position, and when the control member is placed in a selected operative position, the fluid in the main spool chamber is pressurised to urge the main spool to an open position depending on the selected position of the control member wherein fluid is permitted to pass through the valve from the inlet to a selected load outlet.

The control member may be received within a passageway within the control valve and be movable from the neutral position into one of a range of operative positions whereby the fluid may be directed to a selected one or a selected plurality of load outlets. The fluid flow to the load outlet or outlets may be also controlled by the control member although it will be understood that the amount of fluid which flows through the valve is primarily dependent on the position of the operating member. Thus for example, where the fluid operated apparatus comprises a double acting hydraulic ram, one load outlet may be operatively connected to the apparatus to extend the ram, and another load outlet may be operatively connected to the apparatus to retract the ram. Further, more than one control member may be provided within the valve, each control member having an associated load outlet or outlets operatively connected to a fluid operated apparatus, whereby the control valve may be utilised to operate more than one fluid operated

apparatus. However, it will be appreciated that only one operating member need be provided.

Where the valve inlet is connected to a variable output pump, the signal from the control valve may be derived from within the main spool chamber of the control valve in which the pressure of fluid is dependent upon the position of the control member.

According to a second aspect of the invention we provide a fluid control system comprising a fluid operated apparatus, variable output pump means to pump fluid to the apparatus via a control valve having a fluid inlet and a fluid outlet, the fluid outlet being operatively connected to the fluid operated apparatus, the output of the variable output pump being adjustable in response to a signal provided from the control valve which indicates the fluid requirements of the fluid operated apparatus.

The control valve may comprise a valve according to the first aspect of the invention and, in this case, the signal provided from the control valve may be derived from the main spool chamber of the valve.

According to a third aspect of the invention we provide a method of operating a fluid operated apparatus comprising the steps of pumping fluid with a variable output pump to a fluid inlet of a control valve, the control valve comprising a fluid outlet operatively connected to the fluid operated apparatus, and varying the pump rate in response to a signal from the control valve which indicates the fluid requirements of the fluid operated apparatus.

The invention will now be described with the aid of the accompanying drawings, in which:-

FIGURE 1 is a first section through a fluid control valve embodying the invention;

FIGURE 2 is a second section through the fluid control valve of Figure 1 showing a control spool thereof in a neutral position;

FIGURE 3 is a section similar to that of Figure 2 but showing the control spool in an operative position.

FIGURE 4 is a schematic diagram of a fluid control system having a fluid control valve embodying the invention.

Referring to Figures 1 to 3 of the drawings, there is shown a fluid control valve 10 for use in a hydraulic system. The valve 10 has a fluid inlet 11 to which fluid is supplied from a fluid reservoir under pressure, by a fixed output pump, two load outlets 12 and 13 either of which may have fluid directed thereto, through the valve 10, from the inlet 11, and a drain outlet 14 which communicates with the fluid reservoir to which fluid may be returned.

The control valve 10 may control a fluid operated apparatus comprising a double acting hydraulic ram or a group of such rams, wherein fluid is supplied to the ram or rams from an outlet 12 for example of the control valve 10, to extend the ram or rams, and from the other outlet 13 to retract the rams. Where the ram or rams are extended, fluid from the ram passes back to outlet 13, which acts as a return inlet, from where the fluid is directed to the drain outlet 14 and hence returned to the fluid reservoir, as hereinafter described. Similarly, when the ram or rams are retracted, fluid passes back to outlet 12 which acts as a return inlet, and from where the fluid is directed to the drain outlet 14 and hence returned to the fluid reservoir.

The amount of fluid required to be passed through the valve 10 to outlet 12 or 13, depends on the speed at which it is desired to operate the ram or rams.

The control valve 10 further comprises a common feed gallery 15 into which fluid is permitted to pass from the inlet 11 through a throat T formed between a shoulder 19a of a land 19 of an operating member comprising a main spool 18, when the main spool 18, which is slidable in a

passage 18a in the valve 10, is urged into an operating position as shown in Figure 1 against the force of a coil compression spring 17, which urges the spool 18 to the right as seen in Figure 1.

As the main spool 18 moves to the right from the position shown in Figure 1, communication between the inlet 11 and the common feed gallery 15 is progressively reduced and ultimately prevented.

The throat T provides a restriction in the flow path from the inlet to the feed gallery 15 so that there can exist a pressure difference between the inlet 11 and the feed gallery 15. The shoulder 19a and throat T are of such configuration that the magnitude of the restriction varies smoothly with the position of the spool 18, reducing as the spool 18 moves to the left.

When the spool 18 is in the Figure 1 position, fluid may pass from the inlet 11 to the feed gallery 15 and hence into a chamber 15a (Figure 2) which communicates via a non-return valve 20, with a distribution passageway 22 from where the fluid may pass to a selected one of the outlets 12, 13, depending upon the position of a control member comprising a control spool 24 which is slidable in a control spool chamber 24a (Figures 2 and 3) of the valve 10.

The non-return valve 20 has a shoulder 20a on which the pressure of fluid in chamber 15a acts, the shoulder 20a being of greater area than the sealing area 20b thereof and thus as the pressure in the distribution passageway 22 increases as the pressure at a selected load outlet 12, 13, increases, the valve 20 is opened so that fluid flows from the chamber 15a via the valve 20 into passageway 22 and hence to outlet 12 or 13. The load pressure at the selected outlet 12 or 13 is thus transmitted, when the valve 20 is open, to the feed gallery 15.

Figure 3 shows the control spool 24 in a right operative position, in which position fluid is allowed to

pass from the distribution passageway 22 to the outlet 12 via a main land 26 provided on the control spool 24 to extend the ram or rams. Fluid which is passed back from the ram or rams to outlet 13, which acts as a return inlet, passes via a further land 27 into a tank galley 59. When the control spool 24 is in an opposite left operative position, fluid is allowed to pass from the distribution passageway 22 to the outlet 13 via the further main land 27 in the control spool 24, to retract the ram or rams. Fluid which is passed back from the ram or rams to outlet 12, which acts as a return inlet, passes via land 26 into a second tank galley 63.

Figure 2 shows the control spool 24 in a neutral position wherein fluid is prevented from passing from the distribution passageway 22 to either of the outlets 12 and 13.

The position of the control spool 24 is manually controlled in the valve 10 shown, by a manually operable control mechanism 28 which comprises an operator controlled lever 30 pivotable about pivot axis 31, the lower end 32 of the lever being pivotally received in a recess 33 of the control spool 24 so that as the lever 30 is rotated clockwise as seen in the drawings about pivot axis 31, the control spool 24 is moved to the left, and conversely as the control lever 30 is moved anti-clockwise, the control spool 24 is moved to the right.

When the control lever 30 is upright, the control spool 24 is in the neutral position, as shown.

Referring again to Figure 1, a spring biased compensating spool 35 is provided whereby the proportion of fluid from the inlet 11 directed to a selected load outlet 12, 13, and/or to main drain outlet 14 is metered thereby ensuring a controlled flow of fluid at the load outlet 12 or 13 as required, thereby improving the control characteristic of the valve 10. The spool 35 is slidable in a compensating spool chamber 47a.

The spool 35 has a land 35a and, depending on the position of the spool 35 in the chamber 47a, fluid may pass from the inlet 11 via lower part 11b thereof, through a passage 60 past land 35a, to the tank gallery 59 and hence to the main drain outlet 14 via a communicating ducts, which cannot be seen in the drawings.

The right-hand end 38 of the spool 35 is slidably received in an end chamber 47 of chamber 47a. The spool 35 has an aperture 36 therein through which a proportion of the fluid from the lower part 11b of the inlet 11 passes and hence passes into a central passage 37 within the spool 35. This fluid acts on the end 38 of spool 35 to urge the spool 35 to the left, outwardly of the chamber 47. A proportion of fluid from feed gallery 15 (the pressure of which is dependent upon the pressure at a selected load outlet 12 or 13 passes through an aperture 60a smaller than aperture 36, in the lefthand end 39 of the spool 35 and, along with a coil spring 40, provided at the end 39 of the spool 35, counteracts the fluid pressure at the right end 38 of the spool 35.

If the load pressure decreases, for example as control spool 24 is moved to a neutral position and thus the pressure in gallery 15 and thus acting on the end 39 of the spool 35 decreases, the spool 35 will move to the left as fluid from the central passage 37 acts on the end 38 of the spool 35 in the chamber 47.

As the spool 35 moves to the left, the land 35a of the spool 35 will permit an increasing amount of fluid to pass from the lower end 11b of the inlet 11, via the duct 60 into tank gallery 59 and hence to the main drain outlet 14, and thus the pressure of fluid at the inlet 11 will be caused to decrease as the resistance to the flow of fluid to the drain outlet is low. However the inlet pressure will be maintained slightly greater than the load pressure, due to the action of spring 40.

Conversely, if the load pressure increases. For example if the control spool 24 is manually moved to the

right operative position shown in Figure 3, the pressure at the end 39 of the spool 35 will urge the spool 35 to the right thus decreasing the amount of fluid permitted to escape to the tank gallery 59 and thereby increasing the proportion of fluid available to be directed to the load outlet 12 and thus causing the pressure at the inlet 11 to increase to maintain the pressure at the inlet 11 slightly greater than the load pressure.

Thus the spool 35 will achieve an equilibrium position balanced between the pressure of fluid at the inlet 11 which acts on the end 38 of the spool 35 and the load pressure which is transmitted via gallery 15 to the end 39, along with the force of the spring 40.

The quantity of fluid which escapes to the tank gallery 59 is therefore metered by the spool 35 depending on the load pressure, and the inlet pressure is always maintained slightly greater than the load pressure in the gallery 15.

The throat T described hereinbefore permits of the existence of a pressure difference between the inlet 11 and the feed gallery 15, which pressure difference is maintained by the above described variation in the proportion of fluid which passes from the inlet 11 to the tank gallery 59. Of course, if it is desired that the inlet pressure is maintained equal to the load pressure, this can be achieved by altering the strength of the spring 40 and the relative areas of the spool 35 acted upon by the inlet and outlet pressures accordingly. In this case, although the throat T would again permit of the existence of a pressure difference, this would be prevented.

At the end 39 of the compensating spool 35, a pressure release valve 62 is provided to limit the fluid pressure in the region 61 of the chamber 47a at the end 39 of the spool 35.

Fluid which escapes via the pressure release valve 62 passes into the second tank gallery 63 which also

communicates with the main drain outlet 14 by a communication duct which cannot be seen in the drawings.

The size of the duct 60a is very small compared with the size of the aperture 62a of the release valve 62, so that if the pressure in the region 61 of the chamber 47a increases above a predetermined value, due for example to an increase in the load pressure when the valve is actuated, the release valve 62 will be opened and the pressure of fluid in the region 61 will thus be maintained below the predetermined value. The maximum load exerted on the fluid controlled apparatus will thus be restricted.

The outlets 12, 13 are also each provided with pressure release valves 64, 65 so that over pressurisation at the outlets 12, 13 cannot take place.

A regulating spool 41 having radial apertures 42 and a central passage 43 is slidable in a passage 41a in an axial bore of the main spool 18 to maintain the pressure in a main spool chamber 52 in which the right hand end of main spool 18 is received, substantially constant irrespective of the load pressure which is transmitted to the inlet 11 by throat T.

A proportion of the fluid from the inlet 11 passes into apertures 48 in the main spool 18 and through the aligned radial apertures 42 of the regulating spool 41 into the central passage 43 within the spool 41, from where some fluid escapes by a narrow jet 75 to the main spool chamber 52.

The chamber 52 communicates with a metering orifice 53 (Figure 3) adjacent the control spool 24 to which fluid is directed from the chamber 52.

When the control spool 24 is in the neutral position (i.e. Figure 2 position), the orifice 53 is aligned with graduated lands 54 of the control spool 24 which allows fluid to pass from chamber 52 through orifice 52, and escape via a communicating duct (not shown) to the main drain outlet 14.

When the metering orifice 53 is open, i.e. aligned with the associated lands 54, the main spool 18 is held in the above mentioned right position by the coil spring 17 which acts on the rear end thereof, because the pressure in the chamber 52 is insufficient to lift the main spool 18 from the chamber 52 against the force of the spring 17. Thus, the entry of fluid from the inlet into the feed gallery 15 and hence to a load outlet 12, 13 is blocked and no fluid can enter the gallery 15 from the inlet 11 as throat T is closed. Thus the compensating spool 35 will be urged by the inlet pressure, to its fully left hand position as the pressure in region 61 of chamber 47a will be overcome, so that all the fluid fed to the inlet 11 will be directed to the main drain outlet 14.

When the control spool 24 is moved into either to the right or left operative positions, for example the right operative position shown in Figure 3, escape of fluid via the associated land 54 is restricted which results in a pressure build-up in chamber 52. Thus the main spool 18 will be moved against the force of the spring 17 to the operative position hereinbefore described, to permit fluid to pass from the inlet 11 into feed gallery 15 and hence to the associated outlet 12 or 13 depending on the control spool 24 position.

As the main spool 18 thus moves, the restriction provided by the throat T will be reduced so that the pressure difference between the feed gallery 15 and the inlet 11 will tend to fall, and as a result, the compensating spool 35 will move to the right, allowing a greater proportion of fluid to become available to flow into the gallery 15 and hence be directed to the selected load outlet 12 or 13. In this way, the flow rate of fluid from the inlet to a selected load outlet is controlled.

A drain outlet P is provided in the rear left end of spool 18, to allow any fluid trapped at the rear end 46 of the regulating spool 18 to escape, as the spool 18

moves to the left. This outlet P is blocked when the spool 18 is in a right position where the throat T is closed, so that the fluid cannot pass from the rear end 46 of spool 18, to the drain outlet 14.

It can be seen that, as shown, the lands 54 of the control spool 24 are graduated so that escape of fluid and pressure build-up in the chamber 52, and hence the extent of movement of the main spool 18 are directly dependent upon the extent to which the control lever 30 is moved.

When the control spool 24 is again moved to its neutral position, the pressure in chamber 52 will be reduced as the fluid escapes via lands 54 to the main drain outlet 14.

Thus the spring 17 will act to again move the main spool 18 into its inoperative position so that the fluid flow into the feed gallery 15 is progressively reduced to zero.

As fluid flow into the feed gallery 15 decreases the pressure difference between the feed gallery 15 and the inlet 11 increases and thus the spool 35 will be moved to the left to allow more fluid to escape via duct 60 to the tank gallery 59.

When the control lever 30 is at its extreme right or left operative position, the main spool 18 may move to the left to such an extent that the tank gallery 59 will communicate with the chamber 52 and thus the pressure build-up in chamber 52 will be limited and further movement of the main spool 18 prevented.

Fluctuations in load pressure, for example if the load on the fluid operated means suddenly increases or decreases, tends to cause fluctuation in the pressure of fluid in feed gallery 15 and hence in central chamber 43 within spool 41 and thus the main spool 18 would be further moved to either allow more fluid or less fluid to enter feed gallery 15. To prevent fluctuations causing this, and to achieve a more controlled characteristic,

the spool 41 is arranged to be urged to the left as load pressure increases, by fluid acting on the right end 44 thereof in a regulating spool chamber 49, against the resilient force of a spring 45 which acts at the other end 46 of the spool 41.

If the load pressure suddenly increases, the spool 41 will be moved to the left to such a degree that the apertures 42, 48 will become increasingly misaligned, and thus provide an increasingly blocked duct so that the fluid supply to the central passage 43 of the spool 41 will, at a threshold be completely cut off, until the pressure of fluid in the chamber 49 decreases below the threshold, as fluid escapes via jet 75.

The force of the spring 45 on the end 44 of the spool 41 will then overcome the fluid pressure on the end 44 and the spool 41 will again be moved to the right and the apertures 42, 48 will again be aligned and the fluid will again enter the passage 43.

Thus by suitable design of the springs 40, 45 and suitable choice of the size of the jet 75, the pressure of fluid in the passage 43 and hence in the chamber 49 will be maintained substantially constant, irrespective of changes in load pressure.

Thus the pressure of fluid in chamber 52 is prevented from reacting to sudden fluctuations in load pressure.

Thus spool 18 does not respond to sudden fluctuations and hence an easily controlled substantially constant pressure and flow rate fluctuation-free fluid supply will thus be obtained at a selected load outlet 12, 13, the flow rate depending on the position of the control lever 30, more fluid being provided at the outlet 12, 13 and the fluid permitted to escape via passageway 60 to the tank gallery 59 being reduced as the control lever 30 is moved from its neutral position.

In the control valve 10 described, only a small manual effort is necessary to operate the control lever

30 compared with known valves as the high fluid pressures do not act on the control spool 24 but are transmitted to the main spool 18.

The control characteristic of the valve 10 is considerably improved compared to known valves, and as the effort needed to operate the control lever 30 is small, an operator has a fine control of the fluid operated apparatus, increased movement of the lever 30 resulting in a steady increase in speed of the fluid operated apparatus regardless of fluctuations in load pressure.

A further advantage of the valve described is that there are few pressure losses within the valve, and little wasted effort on the pump due to fluid friction and other parasitic losses which normally occur in fluid control valves.

It will be understood that the fluid pressure in main spool chamber 52 will be directly entirely dependent on the position of control spool 24 for the reasons hereinbefore described.

Although in the example described with reference to the drawings, only two load outlets 12, 13 and one associated control spool 24 have been described, if desired, more than two load outlets and associated control spools may be provided, each pair of load outlets having an associated control spool, so that more than one hydraulic ram or set of hydraulic rams can be controlled using only the one control valve. Further, the spools 24 may be controllable each independently by separate control levers 28 or a group of the spools may be controlled by a common lever 28. In this case fluid is supplied to each control spool from the common feed gallery 15. Hence the load pressure obtained in the feed gallery 15 will be the resultant of all the individual load pressures.

The further control spools 24 will each have further metering orifices 53 with lands 54 and will extend parallel to the control spool 24 shown.

However, it will be appreciated that only one main spool 18 is necessary to provide fluid to the control spools and thus the flow rate through the valve is increased compared with known compensated type valves which have a plurality of pressure sensing passages which extend, one from each load outlet, via a series of shuttle valves to feed the load outlet pressure to act on the compensating spool.

Instead of providing a compensating spool 35 as hereinbefore described, the valve 10 may be modified and utilised with a variable displacement pump.

This is achieved by providing the chamber 52 with a communicating passage which extends to a servo control of the variable displacement pump, such as that having a swash plate control.

Thus as the flow rate demand increases, the pump rate is increased and thus more fluid is made available at the inlet 11 of valve 10 to power the fluid operated apparatus.

Conversely, where the flow rate demand is negligible, the pump rate is decreased to a minimum resulting in a saving of the fuel necessary to operate the pump.

Such a fluid control system is shown diagrammatically in Figure 4. The control valve 10 is provided at the inlet 11 with fluid from a reservoir 101 via a variable displacement pump 102, the pump rate of which is controlled by the fluid pressure in a servo pipe 104 which is connected to the connecting passage C of the chamber 52 of the valve 10 which is indicated in chain dotted lines on Figure 1. An outlet such as outlet 12 from the valve 10 feeds hydraulic fluid to a fluid operated apparatus such as a hydraulic ram 110 so as to extend the ram 10, fluid from the ram 110 passing back through to outlet 13 of the valve 10 which acts as a return inlet, to drain outlet 14 to the reservoir 101 via a filter 112. As the flow rate demand for operation of

the ram 110 at a desired speed increases, the pump rate of the variable displacement pump 102 increases and vice versa.

If desired, the compensating spool 35 may be retained when the valve is utilised with a variable displacement pump.

Of course, such an arrangement can be used to control other fluid operated apparatus, and not only a hydraulic ram 110 or group of rams as described.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:-

1. A fluid control valve having an inlet for pressurised fluid, at least one load outlet operatively connected to a fluid operated apparatus, a fluid flow path through the valve from the inlet to the load outlet, at least one control spool, associated with the load outlet the spool being selectively movable from a neutral position, wherein fluid is prevented from flowing from the inlet to the load outlet, to an operative position, wherein fluid is permitted to flow from the inlet to the load outlet, an operating member to meter the flow of fluid through the valve, the operating member comprising a main spool, one end of which is received in a main spool chamber separate from but in communication with the fluid flow path, the main spool being movable between a closed position wherein minimal fluid flow through the valve is permitted, and an open position wherein maximum fluid flow through the valve is permitted, the position of the main spool, being controlled by the pressure of fluid within the main spool chamber which acts on the main spool, fluid being fed to said main spool chamber from a position upstream of the operating member, in the fluid flow path of the valve, the main spool chamber, communicating with graduated lands of the control spool through a passage means so that when the control spool is placed in said neutral position, the fluid in the main spool chamber is not pressurised to urge the main spool from the main spool chamber and thus the main spool remains in the closed position, and when the control member is placed in a selected operative position, the fluid in the main spool chamber is pressurised to urge the main spool towards the open position depending on the selected position of the control spool.

2. A valve according to Claim 1 wherein the valve includes a compensating spool to direct the fluid to a drain outlet of the valve and to the load outlet in a proportion depending upon the load pressure; whereby the compensating spool adopts an equilibrium position with the load pressure and the fluid pressure at the inlet, acting oppositely on the compensating spool.

3. A valve according to Claim 2 wherein a spring means is provided to urge the compensating spool with the load pressure so that that inlet pressure is maintained slightly higher than the load outlet pressure.

4. A valve according to Claim 2 wherein the operating member provides a restriction in the flow path between the inlet and a gallery communicating with the load outlet to permit of a pressure difference between the gallery and the inlet so that the pressure in the gallery can equal the load pressure, the fluid pressure in said gallery acting on the compensating spool.

5. A valve according to Claim 1 wherein fluid is supplied to the valve by a variable displacement pump, the pump rate of the variable displacement pump being automatically adjustable in response to a signal, derived from the position of the operating member, which is dependent on the selected position of the control member.

6. A valve according to Claim 5 wherein the signal from the control valve is derived from within the main spool chamber of the control valve in which the pressure of fluid is dependent upon the position of the control member.

7. A valve according to Claim 1 wherein a regulating spool is provided to regulate the flow of fluid from the fluid flow path to said main spool chamber, the regulat-

ing spool having a portion in sealing sliding engagement with a regulating spool chamber of the valve into which it is urged by a spring means, means being provided to direct fluid from the flow path of the valve into the regulating spool chamber which communicates with said main spool chamber, to urge the regulating spool against the force of the spring means outwardly of the regulating spool chamber, said fluid directing means including a duct which, as the regulating spool moves outwardly of the regulating spool chamber in response to a sudden increase in load pressure, becomes increasingly blocked thereby reducing the flow of fluid to said main spool chamber and thereby preventing the sudden increase in pressure acting on the operating member.

8. A valve according to Claim 7 wherein the regulating spool chamber comprises a bore in the main spool, the main spool having a duct which, as the regulating spool is urged outwardly of the regulating spool chamber, becomes increasingly misaligned with a duct of said fluid directing means.

9. A fluid control system comprising a fluid operated apparatus, variable output pump means to pump fluid to the apparatus via a fluid control valve, the fluid control valve having an inlet for pressurised fluid, at least one load outlet operatively connected to a fluid operated apparatus, a fluid flow path through the valve from the inlet to the load outlet, at least one control spool, associated with the load outlet the spool being selectively movable from a neutral position, wherein fluid is prevented from flowing from the inlet to the load outlet, to an operative position, wherein fluid is permitted to flow from the inlet to the load outlet an operating member to meter the flow of fluid through the valve, the operating member comprising a main spool, one end of which is received in a main spool chamber separate

from but in communication with the fluid flow path, the main spool being movable between a closed position wherein minimal fluid flow through the valve is permitted, and an open position wherein maximum fluid flow through the valve is permitted, the position of the main spool, being controlled by the pressure of fluid within the main spool chamber which acts on the main spool, fluid being fed to said main spool chamber from a position upstream of the operating member, in the fluid flow path of the valve, the main spool chamber, communicating with graduated lands of the control spool through a passage means so that when the control spool is placed in said neutral position, the fluid in the main spool chamber is not pressurised to urge the main spool from the main spool chamber and thus the main spool remains in the closed position, and when the control member is placed in a selected operative position, the fluid in the main spool chamber is pressurised to urge the main spool towards the open position depending on the selected position of the control spool, the output of the variable output pump being adjustable in response to a signal provided from the control valve which indicates the fluid requirements of the fluid operated apparatus.

10. A method of operating a fluid operated apparatus comprising the steps of pumping fluid with a variable output pump to a fluid inlet of a control valve, the control valve comprising an inlet for pressurised fluid, at least one load outlet operatively connected to a fluid operated apparatus, a fluid flow path through the valve from the inlet to the load outlet, at least one control spool, associated with the load outlet the spool being selectively movable from a neutral position, wherein fluid is prevented from flowing from the inlet to the load outlet, to an operative position, wherein fluid is permitted to flow from the inlet to the load outlet an operating member to meter the flow of fluid through the

valve, the operating member comprising a main spool, one end of which is received in a main spool chamber separate from but in communication with the fluid flow path, the main spool being movable between a closed position wherein minimal fluid flow through the valve is permitted, and an open position wherein maximum fluid flow through the valve is permitted, the position of the main spool, being controlled by the pressure of fluid within the main spool chamber which acts on the main spool, fluid being fed to said main spool chamber from a position upstream of the operating member, in the fluid flow path of the valve, the main spool chamber, communicating with graduated lands of the control spool through a passage means so that when the control spool is placed in said neutral position, the fluid in the main spool chamber is not pressurised to urge the main spool from the main spool chamber and thus the main spool remains in the closed position, and when the control member is placed in a selected operative position, the fluid in the main spool chamber is pressurised to urge the main spool towards the open position depending on the selected position of the control spool, said method comprising the step of varying the pump rate in response to a signal from the control valve which indicates the fluid requirements of the fluid operated apparatus.

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4-1

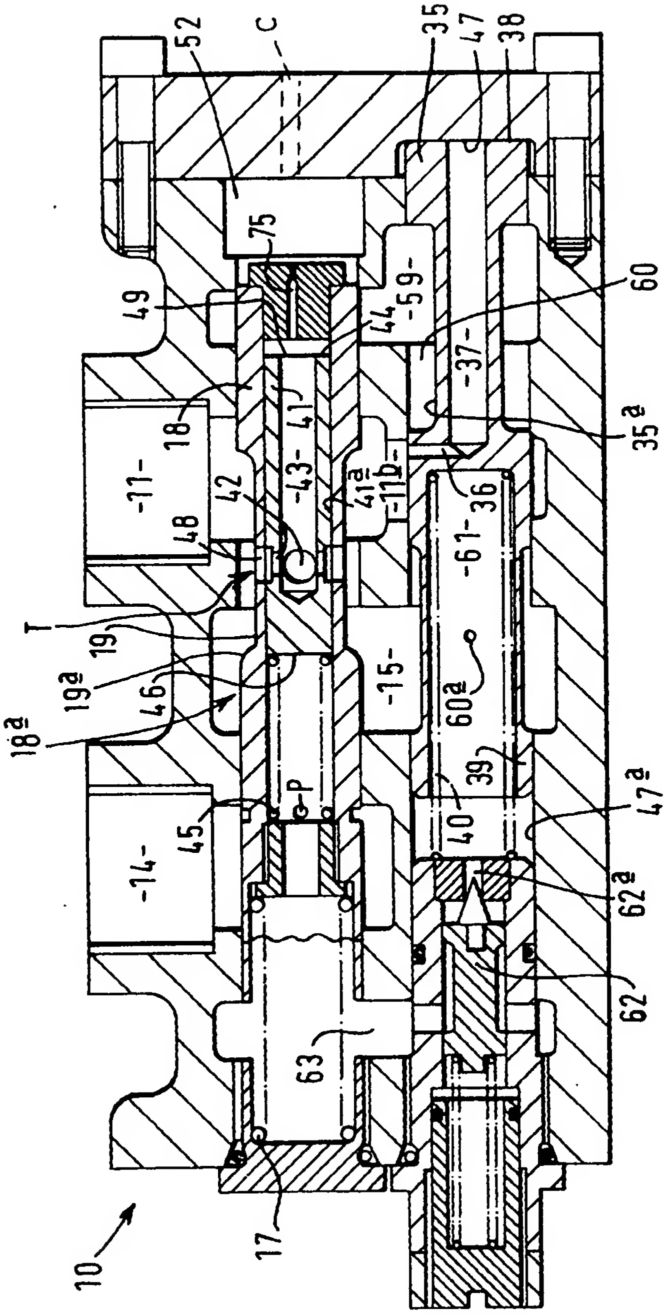

FIG 1

Moss, Barrett, Thompson, Spears

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4-2

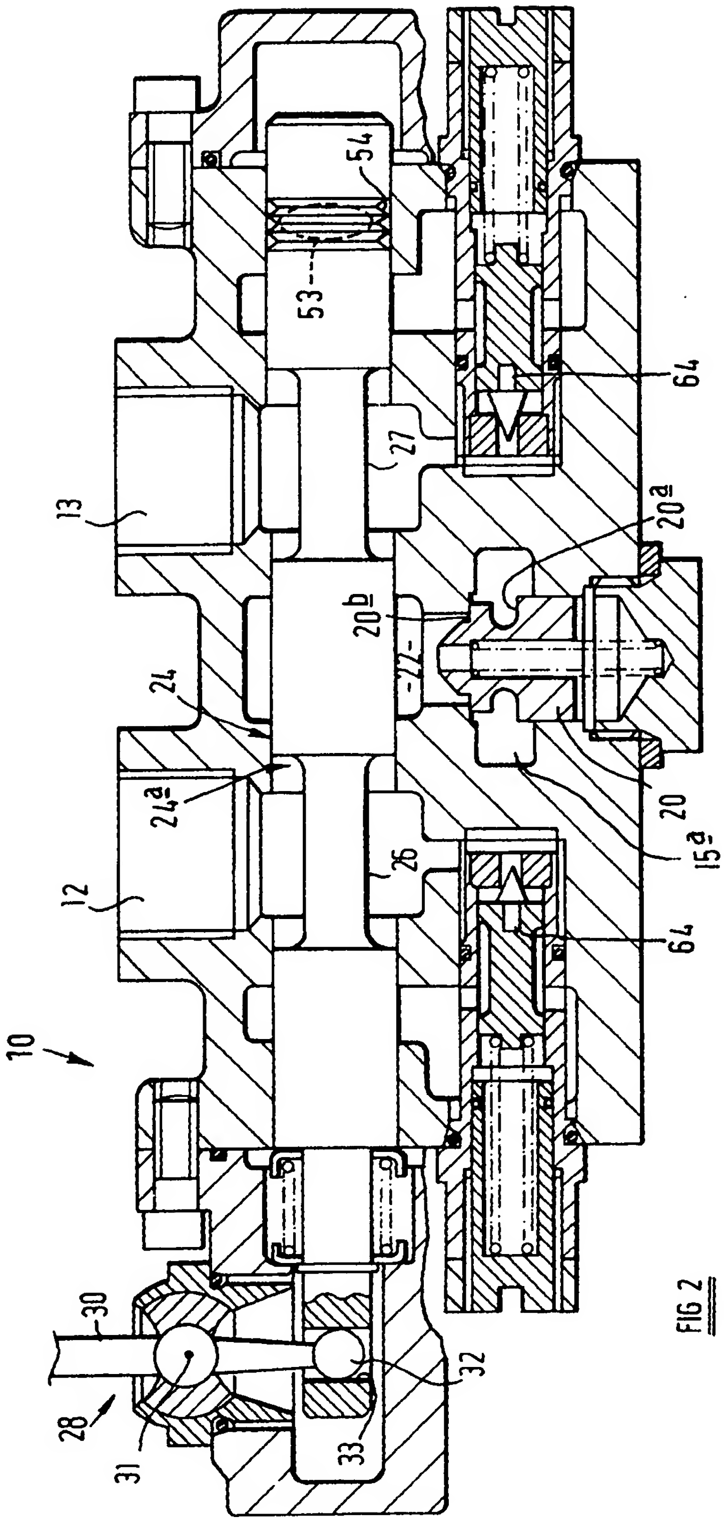

FIG 2

Mess. Boult, Thompson, Squires

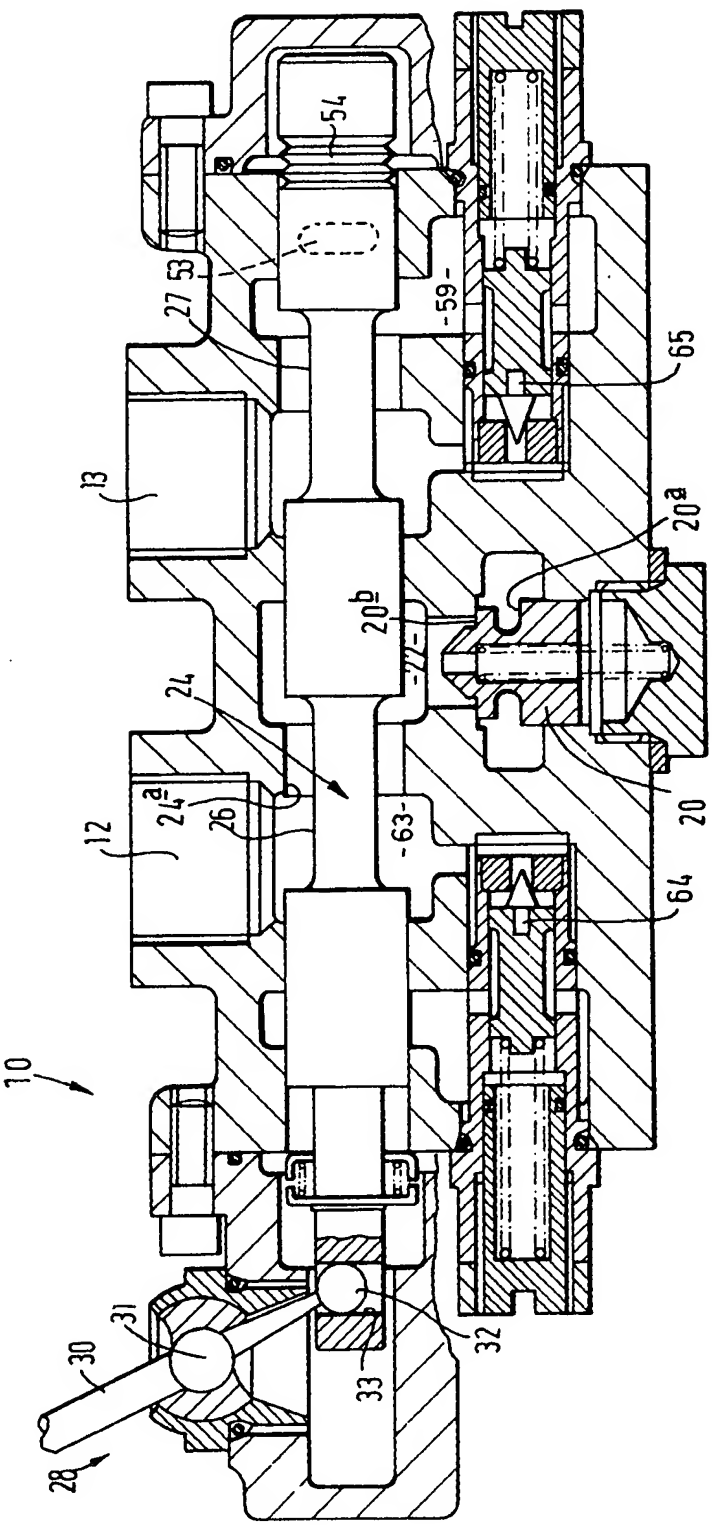

FIG 3

Moss, Bonville, Thompson, Squires

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4-4

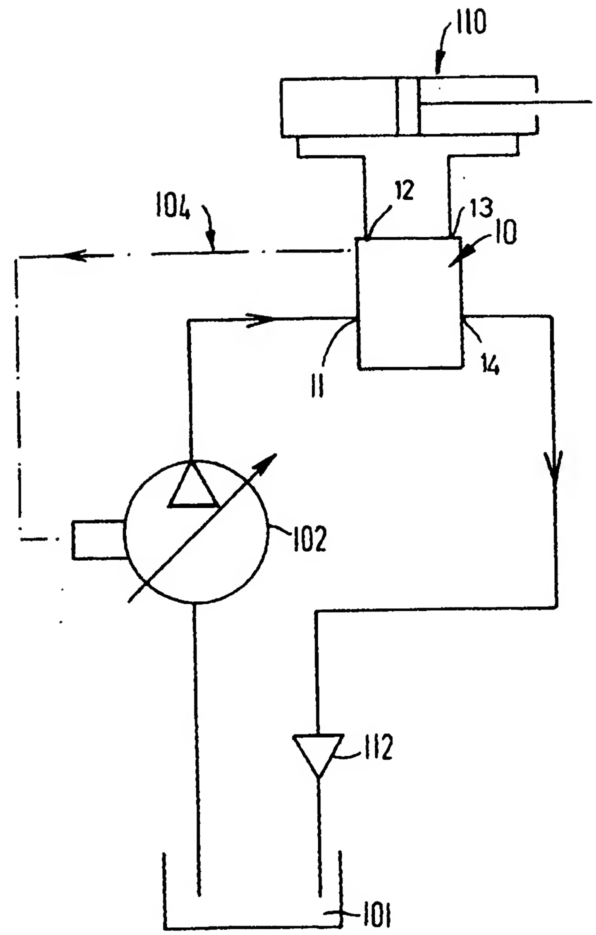

FIG 4

Kiss, Brantle, Thompson, Squire